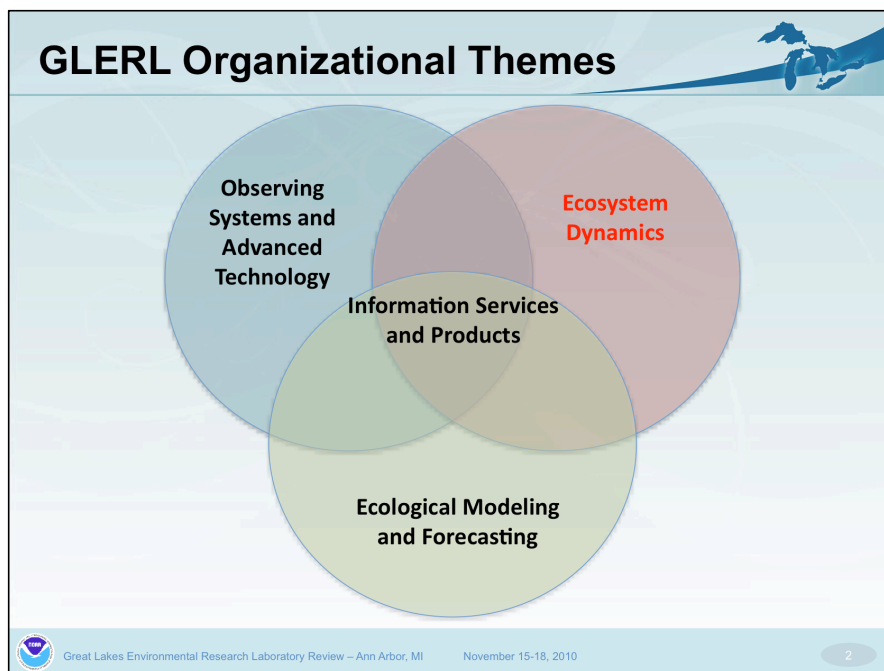


Dr. Ed Rutherford  
Research Fisheries Biologist

This image shows hypoxia in central basin of Lake Erie, a naturally-occurring phenomenon that is getting worse through increased phosphorus loadings and Dreissenid mussel impacts on nutrient cycling.

1

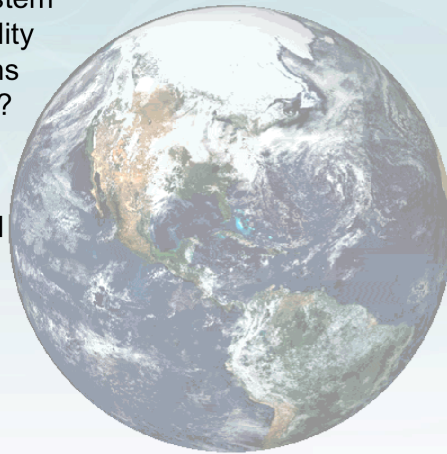


The Ecosystem Dynamics theme group works collaboratively with the Observing Systems and Advanced Technology group, the Modeling and Forecasting group and the Information Services and Products group at GLERL.

2

## Addressing Research Questions in NOAA's 5-Year Research Plan

- What factors influence ecosystem processes and impact our ability to manage aquatic ecosystems and forecast their future state?
- What is current state of biodiversity in the oceans, and what impacts will external forces have on this diversity and how we use our coasts?
- What are causes and consequences of climate variability and change?



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3

GLERL's focus are these strategic research questions in NOAA's 5 year research plan. From 2008 NOAA Research Plan

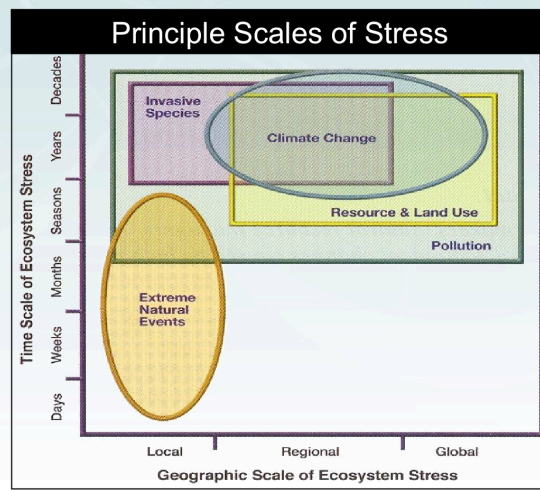
**NOAA's Mission:** *"To understand and predict changes in earth's environment and conserve and manage coastal and marine resources to meet the Nation's economic, social and environmental needs."*

3

## Purpose: To understand the impacts of perturbations on the Great Lakes ecosystem, and to parameterize ecological models

### Key Science question:

How do Multiple Stressors, acting singly or in concert, affect Great Lakes food web and management?



Theme Purpose: To understand the impacts of natural and anthropogenic perturbations on the Great Lakes ecosystem, and to parameterize ecological models that serve as the foundation for GLERL's forecasting capabilities.

Perturbations include invasive species, hypoxia, land-use, climate change, contaminants, nutrient enrichment, and fishery harvest. Historically, NOAA GLERL has worked on all stressors except fishery harvest, but lately has focused on invasive species and nutrient loading impacts. The GLERL lab has a congressional mandate to study invasive species and harmful algal blooms. The diagram comes from the 2008 NOAA research plan.

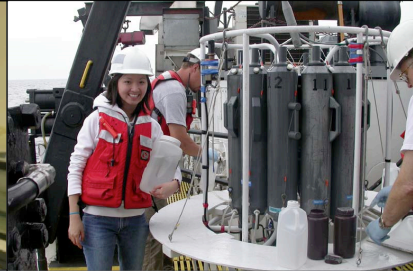
4

# Approach

## Lab and Mesocosm Experiments



## Long-term Surveys and Focused Studies



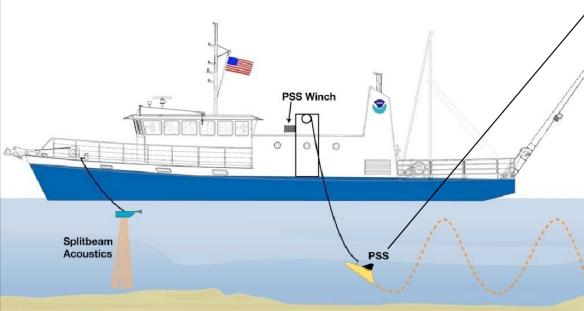
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GLERL conducts both long-term observations of important biological, chemical, and physical variables, and conducts laboratory experiments and field studies to define ecological processes that drive and connect these variables.


5



- Zooplankton
- Temperature
- Dissolved oxygen
- Light levels
- Chlorophyll *a*



- Zooplankton net and pump sampling
- Ponar grabs (benthos)
- Midwater and bottom trawling



### Approach:

GLERL has led major field efforts such as the International Field Years on Lake Erie (IFYLE), involving several investigators from multiple institutions with diverse expertise. (<http://www.glerl.noaa.gov/ifyle/>) Another recent cross-disciplinary research program is the Saginaw Bay Multiple Stressors project. ([http://www.glerl.noaa.gov/res/projects/multi\\_stressors/index.html](http://www.glerl.noaa.gov/res/projects/multi_stressors/index.html))

GLERL has a unique capability to lead these studies because of its fleet of research vessels, scientists with expertise at most trophic levels, and experience with state of the art technology. This slide shows a research survey vessel studying impacts of hypoxia on biota in Lake Erie's central basin during IFYLE.

6

## Approach: Stakeholder-driven, Cross-Disciplinary Projects

- Lake Michigan Mass Balance (Contaminants)
- Hypoxia in Lake Erie, Gulf of Mexico, Chesapeake Bay
- Harmful Algal Blooms (HABs)
- Great Lakes Regional Research Information Network (Invasives)
- Saginaw Bay Multiple Stressors

**Partners:** Federal, state and provincial agencies, and universities in the U.S. and Canada

**Stakeholders:** Great Lakes managers, anglers, communities, scientists



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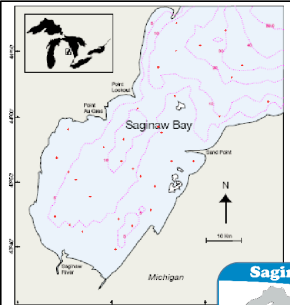
7

GLERL has participated in, or led several large, stakeholder-driven cross-disciplinary studies on issues of concern as shown here.

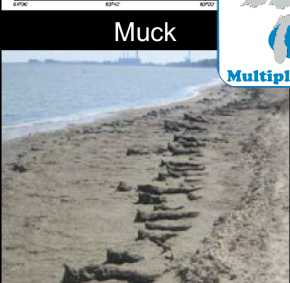
The latest study is the **Great Lakes Regional Research Information Network (GLRRIN)—Predicting Impacts of Invasive Species on Lake Michigan Food Webs**, a project with multiple investigators from Federal and state agencies and universities. (see poster)

Other past projects include: Episodic Event Great Lakes Experiment (EEGLE)— which studied the impact of episodic events on nearshore – offshore transport and biogeochemically important materials on the Great Lakes ecosystem. (<http://www.glerl.noaa.gov/eeagle/>)

7





**Muck**



How can managers improve and restore ecosystem services in Saginaw Bay by understanding synergistic effect of multiple stressors on water quality and fisheries?

- Coordinated field and modeling studies within *Adaptive Integrated Framework*
- Partner with state, federal, academia and Saginaw Bay community

The Saginaw Bay Multiple Stressors project is funded by NOAA Center for Sponsored Coastal Ocean Research for 5 years.

- Endpoints are: fisheries, and water quality
- Inputs of concern: nutrient loading (phosphorus), fishing, land use practices, invasive species, water levels
- Uses novel Adaptive Integrative Framework (AIF): merges *adaptive management* process with *integrated assessments*. Adaptive management process is modified to allow short-term assessment of issues and long-term management of ecosystems. Integrated assessment process is modified to provide rigorous framework for data synthesis and analysis of ecosystem data and communication to stakeholders.
- AIF uses input from agency managers, researchers and modelers, including data to characterize ecosystems and socio-economic factors to drive modeling approaches and management actions.
- An iterative process: Modeling outputs will identify knowledge gaps about impacts of multiple stressors, that in turn drives field and experimental research, and help management agencies identify management alternatives.
- Project captures explicit uncertainty and sensitivity in model outputs that in turn drive future modeling and experimental studies
- Is adaptive to stakeholders concerns (fishing, water quality, muck) and uses results from sampling to guide hypothesis generation and modeling; integrative because of incorporating stakeholders in planning process from the beginning

8



## Products: Long-Term Observations of Lake Michigan

- Dominance of Dreissenid Mussels
- Disappearance of Spring Bloom
- Increased Water Clarity
- Decreased 1° Production



GLERL research regularly receives regional and national attention. The *Journal of Great Lakes Research* has recently devoted a special issue to changes in the lower food web (Vol. 36, Supplement 3, 2010). We also have several papers in a 2009 special issue on hypoxia in the *Journal of Experimental Marine Biology and Ecology* (Vol. 381).

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## Applications: Observations Inform Ecological Forecasts

**Scientists: “Mussels may leave carp nothing to eat”** The Associated Press Sept. 29, 2010, (quoting Fahnenstiel, Nalepa)



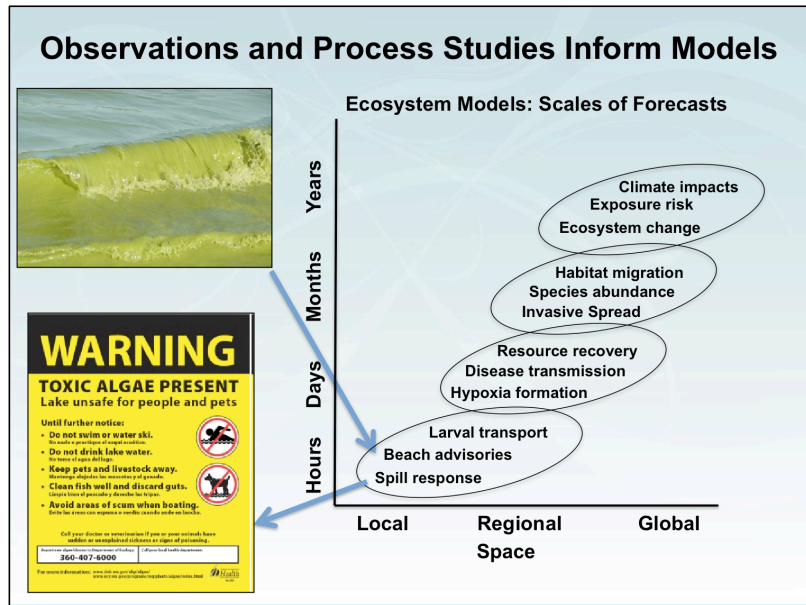
GLERL supports the Great Lakes community by further developing NOAA's role in freshwater/coastal ecology, ecosystems management, and coastal management for the benefit of resource managers, decision makers, and society.

GLERL's observations and process studies provide information on current and new issues, such as whether Asian carp invasion will impact the Great Lakes.

Shown here is Gary Fahnenstiel informing Dr. Lubchenko (NOAA Administrator) about the status of the Lake Michigan ecosystem. Gary recently predicted that Asian carp impacts will be insignificant relative to those from Dreissenid mussels, which have depleted the lakes of primary productivity needed to sustain Asian carp.

GLERL scientists regularly provide information to EPA, lake and provincial resource management agencies, commercial and recreational fishers, and the general public.

10

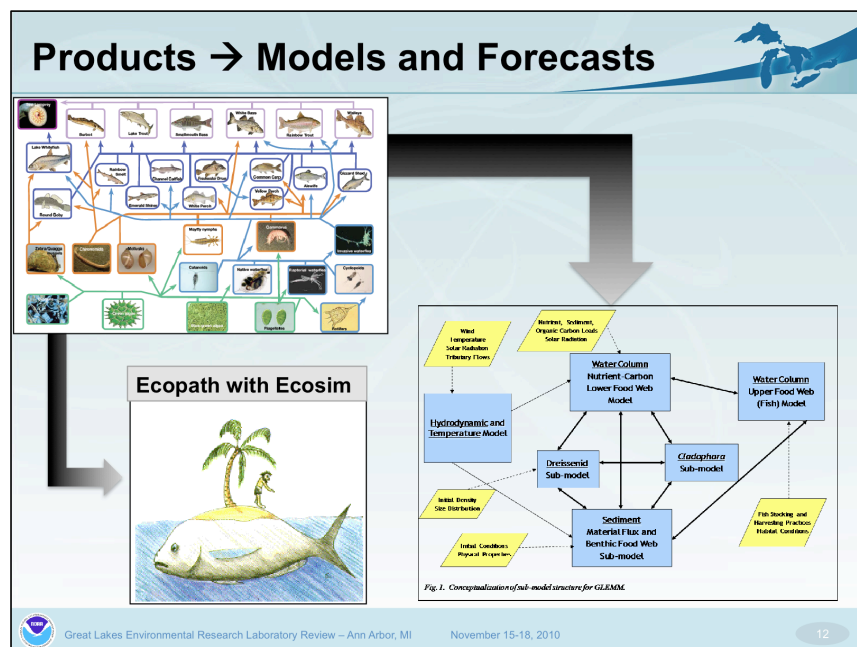


Applications: Inform models to make Ecosystem Forecasts

GLERL has conducted studies on several topics (see figure) that span multiple spatial and temporal scales: Beach advisories, Larvae distributions, HABS, Hypoxia formation, Species distribution and abundance (including invasives), Exposure risk, Ecosystem change, Climate impacts on fisheries

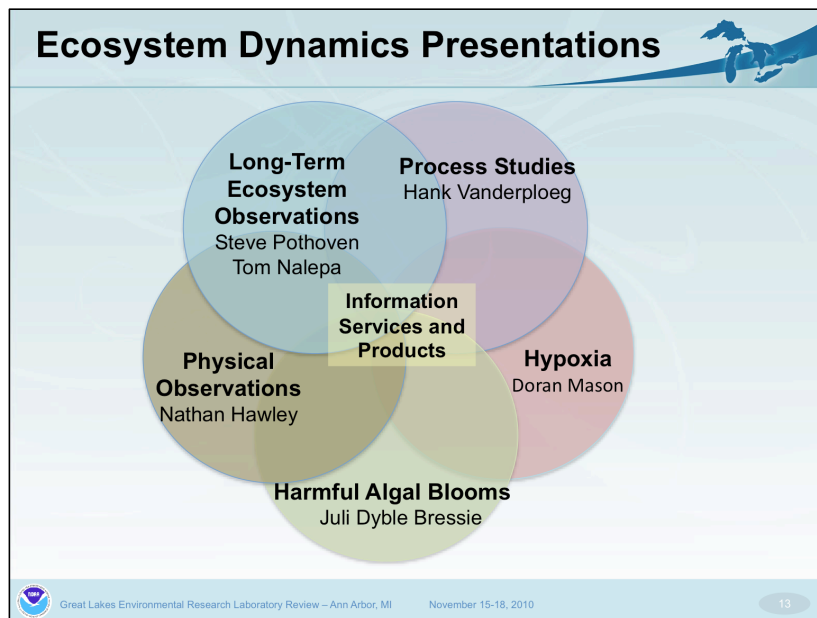
Observations and Process studies then inform models to forecast lake conditions such as the beach advisory shown on the left, which will be described in more detail by Juli Dyble Bressie.

11



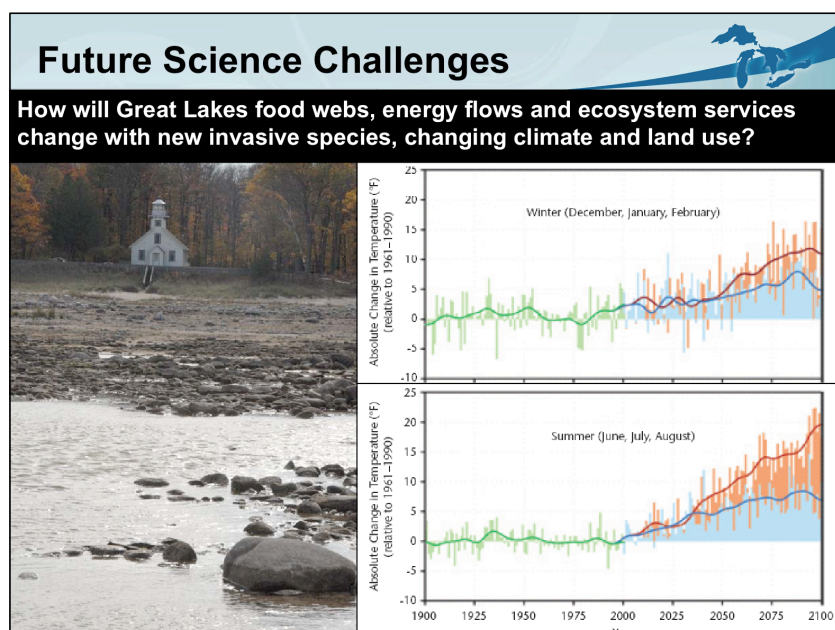
The products from our Ecosystem Dynamics team also inform food web models. Diets, vital rates and biomass densities of key taxa are needed to configure food web models such as EwE (Ecopath with Ecosim) and GLEMM, the Great Lakes Ecosystem Management Model that Hank Vanderploeg will describe. Analogous field sampling efforts inform forecasting models for: Ice, contaminant cycling, hydrodynamics, fish recruitment, HABS, and hypoxia.

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Steve Pothoven, Tom Nalepa: Long-term observations  
 Juli Dyble-Bressie: Harmful algal blooms  
 Hank Vanderploeg: Process studies and experiments  
 Nathan Hawley: Physical measurements  
 Doran Mason: Cross-ecosystem hypoxia studies  
 Please note that cooperative institute scientists play an important role in several of our groups. For example, Tom Johengen and Ashely Burtner of the Cooperative Institute for Limnology and Ecosystems Research characterize nutrient dynamics in the Great Lakes.  
 Also note that our information services group plays a key role in communicating results of our work to stakeholders, and kept updates of invasive species spread (GLANSIS) and water quality and beach advisory forecasts (ECOHAB).

13



GLERL's long term monitoring programs and focused experiments have provided a basis for forecasting impacts of new invasions before they occur. An example of this is the Asian carp, which Fahnenstiel says is a minor threat relative to Dreissenid mussels.

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## Next Generation Strategic Plan: Goals and Objectives

### Climate

- Improved scientific understanding of changing climate system and impacts

### Healthy Oceans

- Improved understanding of ecosystems to inform resource management decisions
- Healthy habitats that sustain resilient and thriving marine resources and communities

### Resilient Coastal Communities

- Comprehensive ocean and coastal planning and management
- Improved coastal water quality supporting human health and coastal ecosystem services

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## Future Research: Healthy Oceans

**GLERL Goals:** Maintain long-term ecological studies program, and enhance GLERL's expertise in lower trophic level ecology, biogeochemistry, and physical process science

**Outcome:** Improved understanding of Great Lakes ecosystems and habitats to inform resource management decisions



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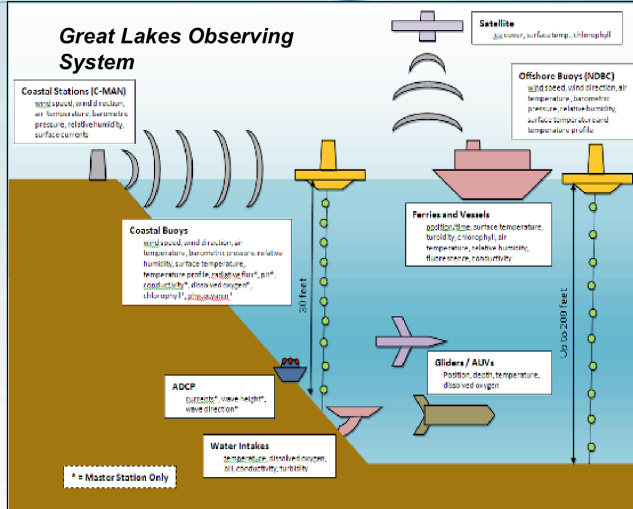
16



## Future Research: Healthy Oceans

**GLERL Goal:**  
Better coordinate real-time sensing of environment with biological sampling, at relevant temporal and spatial scales

**Outcome:**  
Improved understanding of factors influencing energy flow, ecosystem dynamics and health



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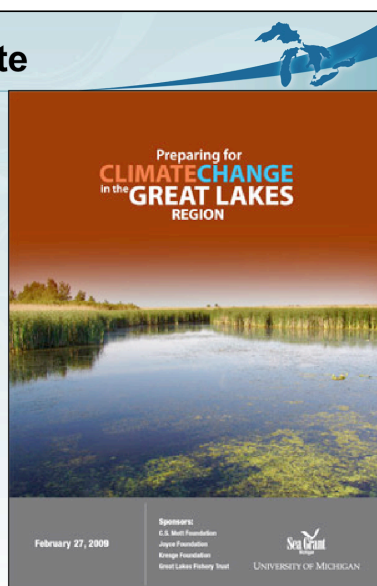
17

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## Future Research: Climate

**GLERL Goal:**  
Relate continuous measures of water temperature, precipitation, lake levels and hydrodynamics to long-term ecological observations

**Outcome:**  
Improved understanding of climate change impacts on ecosystem dynamics and services



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## Future Research: Resilient Coastal Communities

**GLERL Goal:** Continue studies of factors influencing harmful algal blooms, and models to predict bloom development and toxicity

**Outcome:** An improved early warning system for HABS formation and occurrence, leading to improved water quality and healthier communities



Detroit, MI



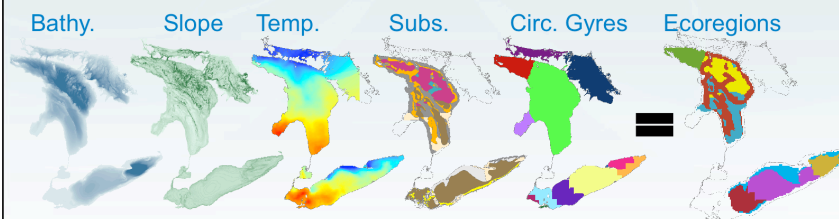
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## Future Research: Resilient Coastal Communities

**GLERL Goal:** Develop landscape-scale spatial framework and geodatabases to support ecological habitat classification

**Outcome:** A framework for ecosystem modeling and management



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We are developing a spatial framework and expanding a basin-wide habitat database called the Great Lakes GIS project to include NOAA's remote sensing and field observations.

(<http://www.glerl.org/glgis>)

These databases are useful for classifying habitats, which will improve understanding of ecosystem function, and support research and management models.

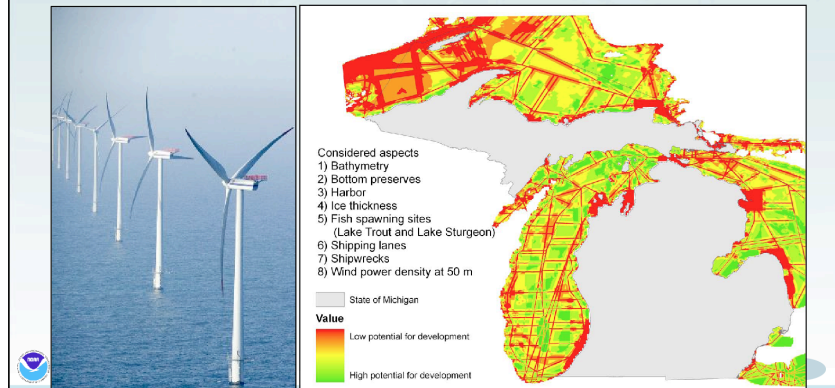
Ecoregion classifications of each Great Lake (Lake Erie and Lake Huron are shown here) are being used as the spatial units for building food web models in two separate research studies funded by NOAA Center for Sponsored Coastal Ocean Research and the Great Lakes Restoration Initiative.

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## Future Research: Resilient Coastal Communities

**GLERL Goal:** Develop landscape-scale spatial framework and geo-databases

**Outcome:** Provide decision support for Coastal Marine Spatial Planning



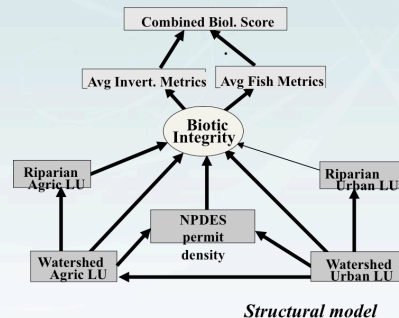
We have developed a decision support tool to evaluate lake-bed alterations in Michigan's coastal waters. Recently we received a grant from U.S. Department of Energy to develop a decision support tool for evaluating windfarm siting in U.S. waters of the Great Lakes. This slide shows the data used to evaluate a gradient of suitability for windfarm siting given criteria developed by Michigan Governor's Offshore Wind Council.

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## Future Research: Resilient Coastal Communities

**Outcome:** Support GLRI project to Define, Quantify Land Use Tipping Points

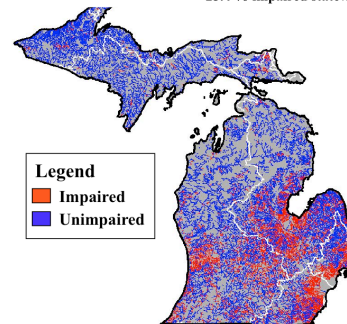
*Measurement model*



*Structural model*

Riseng et al. 2010

**Fish and Invertebrate Community**  
25.4 % impaired statewide



Landscape scale databases for watersheds and the Great Lakes can be applied to determine ecological tipping points for stressor variables.

Agriculture and urban development in the watershed are two land use practices that degrade tributary habitats and increase nutrient loadings or bacterial contamination in nearshore zones.

Here we show an example of index stressor variables such as percent urban or agriculture in tributary riparian or catchment zones. The response variables are biological metrics such as fish or invertebrate presence/absence, community composition or relative abundance. Riseng et al. (2010) recently completed an analysis of tipping point indicators on fish and invertebrate community, and found that 25% of Michigan's Great Lakes tributaries are impaired.

Riseng, C.M., M.J. Wiley, P.W. Seelbach, and R.J. Stevenson. 2010. An ecological assessment of Great Lakes tributaries in the Michigan peninsulas. J. Great Lakes Research 36:505-519.

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## Posters

1. **Jeff Elliott:** Walleye recruitment dynamics in a Great Lakes tributary
2. **JoAnn Cavaletto:** GLRRIN: Shifts in the diel vertical distribution of zooplankton, phytoplankton and fish larvae during spring and summer in Lake Michigan
3. **Hank Vanderploeg:** The Quick and the Dead: fast escape response determined zooplankton community composition after invasion of a visually preying invertebrate cladoceran
4. **Ed Rutherford:** Stable isotope characterization of food webs in the Muskegon River watershed and nearshore Lake Michigan
5. **Juli Dyble Bressie:** Using novel molecular methods to understand environmental controls on *Microcystis* growth and toxicity
6. **Gary Fahnenstiel:** Recent changes in phytoplankton productivity and abundance in the offshore region of Lake Michigan
7. **Gary Fahnenstiel:** An 'enviro-informatic' assessment of Saginaw Bay (Lake Huron, USA) phytoplankton: Characterization and modeling of *Microcystis*
8. **Nathan Hawley:** Sediment resuspension near the Keewenaw Peninsula, Lake Superior



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Open Poster Session: Tuesday, November 16, 11:00 -11:45 a.m. High Bay

Closed (Reviewers only) Poster Session: Tuesday, November 16, 3:35-4:35 p.m. High Bay

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## Take Home Messages

GLERL is a leader in mechanistic studies and observations of stressors facing the Great Lakes ecosystem.

The lab's studies on trophic ecology, biogeochemistry, physical processes and contaminants support models for ecosystem forecasts, and inform scientists, managers, and other stakeholders.



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